Stationarity and Spatiotemporal Dynamics at the Orbital Ordering Transition in the Half-doped Manganite $Pr_{0.5}Ca_{0.5}MnO_3$

Joshua Turner[1,2], Jessica Thomas[3], John Hill[3], Mark Pfeifer[1,2], Karine Chesnel[2*], Y. Tokura[4,5,6],Y. Tomioka[4], S.D. Kevan[1].

[1]Phyiscs Dept., University of Oregon; [2]LBNL, Berkeley, CA; [3]CM Physics, Brookhaven National Lab; [4]Correlated Electron Research Center, National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan; [5]Department of Applied Physics, University of Tokyo, Japan; [6]Spin Superstructure Project, ERATO, Japan Science and Technology Corporation, Tsukuma, Japan;[*]now at LNCMP, Toulouse, France.

Understanding the mesoscale structure and dynamics of complex charge, spin, and orbital-ordered phases is crucial to unraveling the mystery of the colossal magnetoresistance (CMR) phenomenon. The use of coherent soft x-rays allows this complexity to be mapped into far-field speckle-diffraction patterns, which can be analyzed to probe spatiotemporal dynamics, microscopic memory effects, and real-space structures through phase retrieval. We report new coherent soft x-ray scattering experiments performed on beamline 12.0.2.2 at the Advanced Light Source wherein we probe the structure and dynamics of orbital domains in $Pr_{0.5}Ca_{0.5}MnO_3$ near the orbital ordering transition temperature. By operating at the Bragg condition for the lowest-order orbital reflection and at a wavelength that is resonant with the Mn L-edge, we have obtained excellent scattering signal with direct sensitivity to the orbital ordered phase. We find that the low temperature state is characterized by static short-range ordered domains and that the system remains largely static as it is warmed through the disordering transition. In addition, we have observed small-amplitude spatiotemporal fluctuations near the transition. We have studied the connection between this small fluctuating component, a decrease in the orbital domain coherence length, and a change in shape of the integrated scattering profile over a narrow temperature range all just below the transition. Our measurements present new insight into how the orbital ordering domain state behaves near the order-disorder transformation - a clue into a key ingredient of the CMR story.